LIFE-FORMS IN THE PLAINS FLORA OF SOUTHERN MACKENZIE, NORTHWEST TERRITORIES

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This paper presents a life-form analysis of the 558 species of seed plants that are reported to be native or naturalized in the Great Plains of southern District of Mackenzie. The life-form classification used here is that of Raunkiaer (1934), which is based on the kind and degree of protection given to the perennating buds during the unfavorable season. Of the several life-form systems that have been proposed, that of Raunkiaer is most widely used, in large measure because of its simplicity and ready applicability.

Apparently the only life-form studies previously made on Canadian floras are those of Raunkiaer (1934), which were first published in 1908, and those of Scoggan (1950). Raunkiaer based his work on such floristic lists as were then available for the regions he chose to analyze. These lists, some of which had been compiled a number of years before Raunkiaer made use of them, were for the most part quite incomplete accounts of the various floras. As a result, the life-form studies based on them present statistics and conclusions that may not be entirely valid. Scoggan's studies, in contrast, were based on his own and other relatively complete and recent accounts of the eastern Canadian floras concerned. If the Raunkiaer system of classification of life-forms is to be tested for boreal America, many additional life-form analyses are needed. The present paper is offered as a contribution to this end.

The Great Plains of southern Mackenzie extends from the Laurentian Plateau on the east to the Mackenzie Mountains on the west and from the Mackenzie-Alberta border (60°N) on the south to latitude 62°N on the north. The area encompassed is about 45,000 square miles. Elevation varies from about 520 feet at Great Slave Lake to 1600 feet in the Mackenzie Lowlands east of the Liard River. The region lies wholly within the boreal forest and principally in the

Mackenzie Lowlands. The climate can be described as northern continental, with short, dry, and relatively warm summers and long cold winters. (see climatological data in Table 1).

The region was chosen for life-form analysis because of three main considerations. First, the flora of the Great Plains of southern Mackenzie is better known than that of any other large portion of the district and is on record in

Table 1.

Climatological data for Fort Simpson, Hay River, and Fort Smith, N.W.T. (from Anonymous, 1954).

	Fort Simpson	Hay River	Fort Smith
Mean annual precipitation in inches	12.13	12.02	12.63
Mean annual rainfall in inches	7.61	7.34	7.97
Mean June, July, and August rainfall in inches	5.46	4.06	5.05
Mean January temperature in degrees F	—15	—12	—13
Mean July temperature in degrees F	62	60	61

relatively few publications (Cody, 1957, 1961; Jeffrey, 1961; Raup, 1947; and Thieret, 1961, 1962, in press). Second, the over-all climate of the region appears not to vary markedly either from east to west or from north to south, as can be seen by examining climatological data (Table 1) from Fort Simpson, Hay River, and Fort Smith, three widely separated settlements. Third, the author has carried out field work during four seasons of study of flora and vegetation along the Great Slave Lake Highway and has observed in the field and collected about 80 percent of the species considered in the preparation of this paper. Too often, life-form studies are based almost entirely upon herbarium specimens and not upon all-important field observations on the plants concerned.

Raunkiaer's life-form system is completely independent of the usual classification of plants into species, genera, etc., and recognizes five principal classes, which may be characterized as follows.

Class I. PHANEROPHYTES (Ph) bear their perennating buds well above the ground and they are almost all trees and shrubs. Because the buds are elevated and exposed to the full impact of the environment, and because the severity of conditions increases with height above the ground, the phanerophytes are logically subdivided into height classes for life-form analysis: megaphanerophytes (Mg), over 30 meters tall; mesophanerophytes (Ms), between 8 and 30 meters tall; microphanerophytes (Mc), between 2 and 8 meters tall; and nanophanerophytes (N), between 25 centimeters and 2 meters tall. As a class, the phanerophytes are predominant in humid tropical floras and tend to decrease in proportion to other life-forms in regions with climates less favorable to plant growth.

Class II. CHAMAEPHYTES (Ch) have their buds above the ground but lower than 25 centimeters, so that in the unfavorable season they may receive some protection from fallen snow and leaves or from the dense growth of the plant itself. The buds of this class are obviously less exposed to the impact of the environment than are those of phanerophytes. In a general way, the percentage of chamaephytes in a flora tends to increase with increasingly high altitude or latitude or both. An especially high proportion of chamaephytes appears to characterize floras of arctic and alpine regions.

Class III. HEMICRYPTOPHYTES (H) have their buds in the surface of the soil and are thus even better protected than chamaephytes. This class tends to be dominant in floras of temperate regions and often constitutes half or more of the species of an area, especially in grasslands and in deciduous forests; they are also common in tundra except under extreme conditions (Cain, 1950). Raunkiaer distinguished three principal subtypes: the non-rosette or protohemicryptophytes (Hp), the semirosette (Hs), and the rosette types (Hr). The first type is without basal rosettes of leaves; the second has both basal and stem leaves; and the third has its leaves in a compact basal rosette.

Class IV. CRYPTOPHYTES (Cr) have their buds beneath the surface of the soil, in water, or in the substratum under the water. The buds are manifestly much better protected than those of plants whose bud-bearing shoots are in or above the surface of the soil. Raunkiaer recognized three principal subdivisions: geophytes, helophytes, and hydrophytes. Geophytes are land plants, and their perennating structures are commonly bulbs, corms, rhizomes, stem-tubers, or root-tubers. Helophytes grow in soil saturated with water, or in the water itself, but their vegetative shoots are emergent. The hydrophytes include those aquatics that are free-floating and those that root in the substratum beneath the water but whose vegetative shoots are submerged. In the present study, as in most other life-form analyses, the hydrophytes and helophytes are combined into one class (HH). Cryptophytes appear not to be the dominant life-form of any particular climate.

Class V. THEROPHYTES (Th) are annual plants, which survive the unfavorable season in the form of seeds. They are particularly abundant in desert floras and in the weedy communities that develop where native vegetation is disturbed.

The "life-form spectrum" of a particular flora shows the percentage-distribution of the five life-form classes in that flora. Such a spectrum can be used, in comparison with spectra of other floras, to reflect phytoclimatic differences between regions and can give an indication of the type of phytoclimate (i.e., whether phanerophytic, chamaephytic, hemicryptophytic, or therophytic) of the region concerned. Raunkiaer's "normal spectrum" was developed by him as the result of 1000 random samplings of the world flora. It may or may not represent accurately the flora of the world as a whole, but it does serve as a useful standard for comparison. Every regional spectrum will have at least one class whose percentage is higher than that of the normal; this class can be taken as an indicator of the phytoclimate of the region (Oosting, 1956).

The data used in the present study were obtained from field work and from supplementary observations on dried specimens in the herbaria of Chicago Natural History Museum, the University of Minnesota, and the University of Southwestern Louisiana. The field work was supported by Chicago Natural History Museum (1958, 1959) and by a grant from the National Science Foundation (1961, 1962). A few species that have been reported to occur in the southern Mackenzie Great Plains were not considered during the compilation of the data for this paper because these plants are seemingly waifs and not truly naturalized members of the flora.

Table 2.

Life-form distribution of the southern Mackenzie Great Plains flora. Data obtained from the study of 558 species.

	total species		percent of flora	
PHANEROPHYTES (Ph)				
Megaphanerophytes (Mg)	1		0.2	
Mesophanerophytes (Ms)	7		1.2	
Microphanerophytes (Mc)	16		2.9	
Nanophanerophytes (N)	39		7.1	
Total Phanerophytes		63		11.3
CHAMAEPHYTES (Ch)				
Herbaceous chamaephytes (Chh)	23		4.2	
Woody chamaephytes (Chw)	18		3.2	
Total Chamaephytes		41		7.3
HEMICRYPTOPHYTES (H)				
Protohemicryptophytes (Hp)	49		8.9	
Semi-rosette hemicryptophytes (Hs)	214		38.9	
Rosette hemicryptophytes (Hr)	37		6.7	
Total Hemicryptophytes		300		53.8
CRYPTOPHYTES (Cr)				
Helo-Hydrophytes (HH)	41		7.3	
Geophytes (G)				
Rhizome geophytes (Grh)	44		8.0	
Stem-tuber geophytes (Gst)	6		1.1	
Root-tuber geophytes (Grt)	3		0.5	
Bulb geophytes (Gb)	3		0.5	
Root-bud geophytes (Gr)	1		0.2	
Root parasites (Gp)	1		0.2	
Total Cryptophytes		99		17.7
THEROPHYTES (Th)		55		9.8

During the course of the field work, specimens for life-form analysis were collected toward the end of the growing season or even after the first frost in order to assure that the perennating structures would be as nearly as possible in winter condition. Colonies or individuals of the various species were located earlier in the season and were suitably marked for later study. For all collections, data were recorded concerning the position of perennating structures in relation to the soil surface. These field data are especially important in the case of hemicryptophytes and cryptophytes, which may be difficult to assign to the proper life-form class on the basis of herbarium study alone.

Table 3.

Life-form spectrum of the southern Mackenzie Great Plains flora, compared with the "normal spectrum" and with spectra of other North American regions.

	Ph	Ch	H	Cr	Th
Southern Mackenzie Great Plains	11.3	7.3	53.8	17.7	9.8
"Normal Spectrum"	46.0	9.0	26.0	6.0	13.0
Ellesmere Island (Raunkiaer, 1934)	—	23.5	65.5	11.0	—
Baffin Island (Raunkiaer, 1934)	1.0	30.0	51.0	16.0	2.0
Canadian Eastern Arctic (Scoggan, 1950)	3.5	29.4	54.5	10.5	2.1
Sitka, Alaska (Raunkiaer, 1934)	11.0	7.0	60.0	17.0	5.0
Bic and Gaspe (Scoggan, 1950)	10.3	7.8	48.7	18.9	14.1
West and Central Quebec (Scoggan, 1950)	16.6	3.5	43.6	22.4	13.8
Indiana (McDonald, 1937)	15.3	1.7	50.3	19.6	13.0
Illinois (Hansen, 1952)	13.9	2.0	47.5	17.1	14.4
Kentucky (Gibson, 1961)	17.6	1.4	52.6	16.6	11.8
Connecticut (Ennis, 1928)	15.0	1.9	49.4	21.7	11.7
Olympic Peninsula, Washington (Jones, 1936)	11.0	6.0	52.0	22.0	9.0

A tabulation of life-form data for the southern Mackenzie Great Plains is given in Table 2. In Table 3 comparison is made between the "normal spectrum," the spectrum of the Mackenzie plains, and the spectra of several other North American regions.

The following excerpt from Raunkiaer (1934, p. 133) serves well as an introduction to a brief discussion of the data in tables 2 and 3.

> In the northern cold temperate and cold zones as we gradually go towards the north we find that the biological spectrum of the vegetation changes in a very definite manner. The Phanerophytes and the Therophytes decrease and finally disappear. The Cryptophytes, too, which are well represented throughout most of the region, disappear entirely from the hostile regions of the extreme north. The percentage of Hemicryptophytes keeps fairly constant, being approximately double the percentage found in the whole world. The Chamaephyte percentage on the other hand gradually increases towards the north; in the southern parts of the region it is a long way below the Normal Spectrum, but after reaching this figure it soon doubles it. Ultimately the Chamaephyte percentage becomes three times or more that of the Normal Spectrum. All these changes follow the same series everywhere, whichever meridian we follow.

It is evident from the data in Tables 2 and 3 that the phytoclimate of the southern Mackenzie Great Plains is decidedly hemicryptophytic. The hemicryptophyte percentage is about double that of the "normal spectrum," in line with Raunkiaer's assertion. Although Raunkiaer states that the percentage of hemicryptophytes keeps fairly constant in the northern cold temperate and cold zones, there seems to be a tendency for this class to increase somewhat, to a point at least, with increase in latitude and with accompanying decrease in phanerophytes and therophytes. The significance and constancy of this tendency cannot be known until many more life-form data are available than at present.

The phanerophyte percentage is, as could be expected, somewhat lower than that of regions further south. The total percentage and the phanerophyte-subdivision percentages provide statistical demonstration of the well-known phenomenon that the stature of woody plants is progressively reduced as the continental tree-limit is approached. About 130 feet is the maximum height for trees in the southern Mackenzie Great Plains. The only megaphanerophyte is *Picea glauca;* all other trees in the region *(Picea mariana,* *Pinus banksiana, Abies lasiocarpa, Larix laricina, Betula papyrifera, Populus tremuloides,* and *P. balsamifera)* are mesophanerophytes here but may be megaphanerophytes further south. Other good examples of the change in life-form of woody plants with increase in latitude are seen in *Prunus virginiana* and *P. pensylvanica,* which in southern Mackenzie, at the northern edge of their range, are nanophanerophytic, reaching about 5 feet in height. Further south each of these species may be mesophanerophytic, reaching at least 30 feet in height.

The chamaephyte percentage is considerably above the percentage of this class shown by floras of parts of North America with a climate more favorable to plant growth. This relationship is in harmony with Raunkiaer's postulate that the chamaephyte percentage in floras tends to increase with increase in latitude. Of particular interest in the southern Mackenzie Great Plains flora is the preponderance of herbaceous forms among the chamaephytes.

According to Raunkiaer, the cryptophytes are well represented throughout most of the northern cold temperate and cold zones. They are well represented in the southern Mackenzie Great Plains flora, the percentage being neither greatly above nor greatly below the percentage for other studied North American floras, except those in the extreme north.

In connection with the therophyte percentage in the southern Mackenzie Great Plains flora it should be noted that most of the introduced plants in the region are annuals and that these introduced annuals constitute one-half of the therophyte population. The subarctic climate is, of course, not too favorable to the therophytic habit; it may account for the low percentage (4.9) of native therophytes in the flora and may explain, in part at least, why more introduced annuals are not present.

In summary, the data in this life-form study indicate that a climate most suitable to hemicryptophytes prevails in the southern Mackenzie Great Plains. Those data are generally in harmony with Raunkiaer's assertions concerning the change in life-form spectra of floras in cold temperature and cold zones with increase in latitude.

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